Supplementary Materials: Characterizing Land Surface Phenology and Exotic Annual Grasses in Dryland Ecosystems Using Landsat and Sentinel-2 Data in Harmony.

Neal J. Pastick [1,*], Devendra Dahal [1], Bruce K. Wylie [2], Sujan Parajuli [1], Stephen P. Boyte [1], Zhouting Wu [3]

[1] KBR, contractor to the U.S. Geological Survey, Earth Resources Observation and Science Center, Sioux Falls, SD 57198, USA; ddahal@contractor.usgs.gov (D.D.); sparajuli@contractor.usgs.gov (S.P.); sboyte@contractor.usgs.gov (S.P.B.)
[2] U.S. Geological Survey, Earth Resources Observation and Science Center, Sioux Falls, SD 57198, USA; wylie@usgs.gov
[3] U.S. Geological Survey, National Land Imaging Program, Flagstaff, AZ 86001, USA; zwu@usgs.gov
* Correspondence: past0042@umn.edu

Table S1 Average statistical metrics (±SD) derived from observed and predicted normalized difference vegetation index (NDVI * 100) values (2016–2018) for random hold-out samples and 6-tile models constructed across the spatial domain (n=6). NDVI is scaled (100× + 100) to an 8-bit unsigned integer.

Week of year	r	MAE	rMAE	n
7	0.80 ± 0.14	4.7 ± 1.6	0.17 ± 0.04	27601
8	0.76 ± 0.16	4.8 ± 1.2	0.18 ± 0.04	18211
9	0.79 ± 0.15	4.5 ± 1.7	0.16 ± 0.04	36653
10	0.80 ± 0.14	5.4 ± 1.6	0.17 ± 0.04	30880
11	0.83 ± 0.09	3.8 ± 1.1	0.14 ± 0.03	67796
12	0.85 ± 0.10	4.4 ± 1.7	0.13 ± 0.04	48925
13	0.91 ± 0.05	3.7 ± 1.2	0.11 ± 0.02	43586
14	0.91 ± 0.11	3.6 ± 1.1	0.11 ± 0.03	66262
15	0.89 ± 0.03	3.7 ± 1.4	0.10 ± 0.04	63225
16	0.96 ± 0.03	2.2 ± 0.7	0.06 ± 0.02	62278
17	0.95 ± 0.01	2.6 ± 0.9	0.07 ± 0.02	81550
18	0.97 ± 0.02	2.1 ± 0.6	0.06 ± 0.01	59953
19	0.97 ± 0.02	2.2 ± 0.5	0.06 ± 0.02	72206
20	0.97 ± 0.02	2.4 ± 0.7	0.06 ± 0.02	101728
21	0.97 ± 0.01	2.2 ± 0.6	0.06 ± 0.02	100485
22	0.98 ± 0.01	1.8 ± 0.5	0.04 ± 0.01	94737
23	0.98 ± 0.01	1.8 ± 0.4	0.05 ± 0.01	92428
24	0.98 ± 0.01	1.8 ± 0.8	0.05 ± 0.01	124718
25	0.98 ± 0.01	1.8 ± 0.9	0.05 ± 0.02	115169
26	0.99 ± 0.01	1.3 ± 0.5	0.04 ± 0.01	116869
27	0.99 ± 0.01	1.4 ± 0.6	0.04 ± 0.01	133887
28	0.99 ± 0.01	1.2 ± 0.5	0.03 ± 0.01	126153
29	0.99 ± 0.01	1.2 ± 0.4	0.03 ± 0.01	136539
30	0.99 ± 0.01	1.3 ± 0.4	0.04 ± 0.01	117831
31	0.98 ± 0.05	1.3 ± 0.5	0.04 ± 0.02	115833
32	0.99 ± 0.01	1.4 ± 0.5	0.04 ± 0.01	113384
33	0.98 ± 0.04	1.3 ± 0.5	0.04 ± 0.02	96230
34	0.99 ± 0.01	1.4 ± 0.6	0.04 ± 0.01	107927
35	0.99 ± 0.01	1.5 ± 0.7	0.04 ± 0.02	118399

36	0.99 ± 0.01	1.5 ± 0.7	0.04 ± 0.01	91660
37	0.99 ± 0.01	1.4 ± 0.5	0.04 ± 0.01	103540
38	0.98 ± 0.03	1.7 ± 0.4	0.05 ± 0.02	97156
39	0.99 ± 0.02	1.4 ± 0.5	0.04 ± 0.01	85426
40	0.97 ± 0.04	2.1 ± 0.9	0.07 ± 0.03	76049
41	0.97 ± 0.04	1.9 ± 0.7	0.06 ± 0.02	24682
42	0.98 ± 0.01	1.6 ± 0.9	0.05 ± 0.03	27601
Overall	0.94± 0.04	2.4 ± 0.8	0.07 ± 0.02	2996078

MAE = Mean Absolute Error

rMAE = relative Mean Absolute Error

Table S2 Predictor variable usage (+SD) across 10 regression tree (RT) models developed using weekly Normalized Difference Vegetation Index (NDVI) inputs, phenometrics, and ancillary data inputs. Predictor usage is defined as the average number of times a variable was used for stratification or within regression models on the model development database.

Average Usage (±SD)	Variable
0.68 (0.03)	Elevation
0.54 (0.02)	End of growing season week
0.51 (0.03)	Maximum NDVI
0.48 (0.02)	Organic Matter
0.48 (0.02)	Slope
0.46 (0.02)	Week 14 NDVI
0.44 (0.01)	Week 20 NDVI
0.44 (0.01)	End of growing season week – Maximum NDVI week
0.43 (0.02)	End of growing season value
0.43 (0.01)	Week 22 NDVI
0.42 (0.06)	Week 16 NDVI
0.41 (0.01)	Week 27 NDVI
0.39 (0.01)	Week 21 NDVI
0.38 (0.02)	Week 28 NDVI
0.38 (0.03)	Start of growing season week
0.38 (0.02)	Week 25 NDVI
0.38 (0.01)	Week 18 NDVI
0.37 (0.03)	Start of growing season value
0.37 (0.01)	End of growing season week - Start of growing season week
0.36 (0.02)	Week of Maximum NDVI
0.36 (0.01)	Week 19 NDVI
0.36 (0.04)	Week 23 NDVI
0.35 (0.01)	Week 26 NDVI
0.35 (0.02)	Week 24 NDVI
0.35 (0.02)	Week 13 NDVI
0.34 (0.03)	% Clay
0.33 (0.02)	Aspect
0.29 (0.03)	Week 17
0.29 (0.02)	Week 15
0.22 (0.02)	Week 11
0.22 (0.03)	Week 10

	Week of Maximum NDVI - Start of growing season week date
0.18 (0.01)	Time
0.15 (0.04)	Week 12

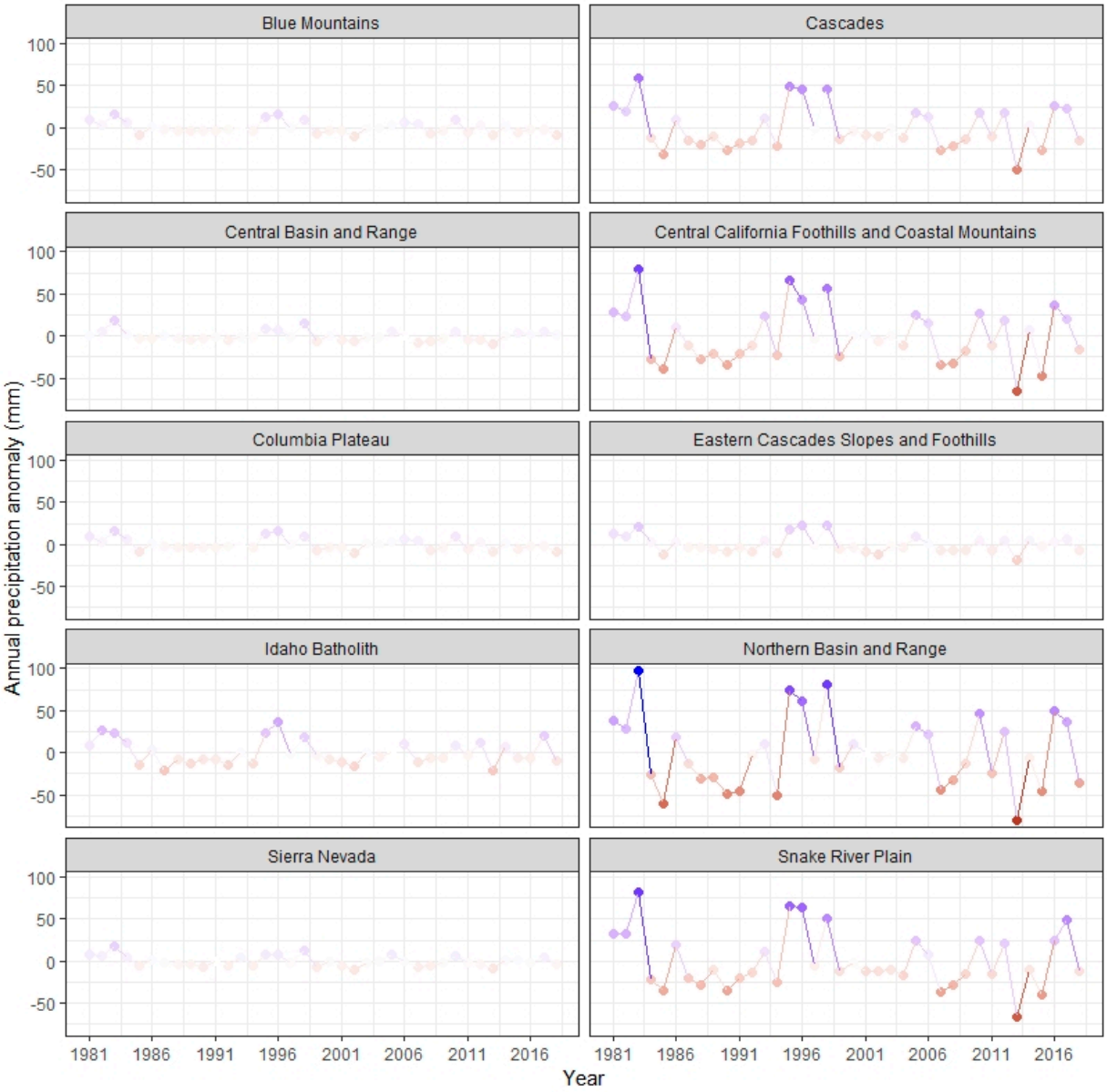

Figure S1 Time series of mean annual precipitation (mm) anomalies for Level III ecoregions (Omernik & Griffith, 2014) derived from PRISM climatologies (4-km × 4-km). Blue and red indicate relatively wetter and drier years, respectively, as compared to 30-yr climate normals (1981–2010).